Spectrum results

with

Kogut-Susskind quarks

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Thanks to:
Claude Bernard
Joachim Hein
Francesco Knechtli
Kostas Orginos

Kogut-Susskind quarks

Staggered quarks $\approx$ Poor man's QCD

Wilson

Flavor symmetry, transparent operators

no chiral sym $\rightarrow$ look for κ_C

$\rightarrow$ exceptional configurations

Errors order a (a^2 with NP clover)

Very expensive to simulate full QCD

Kogut-Susskind

broken flavor symmetry, (order a^2)

$\rightarrow$ hard to figure out operators

one exact chiral symmetry

$\rightarrow m_q = 0$ is chiral limit,

no exceptional configurations

Errors order a^2 ($a^2 g^2$ if improved)

Less expensive to simulate full QCD

Domain wall/overlap

Exponentially small chiral symmetry violations

Flavor symmetry

Errors order a^2

Even more expensive than Wilson

Want 2 or 2+1 dynamical flavors

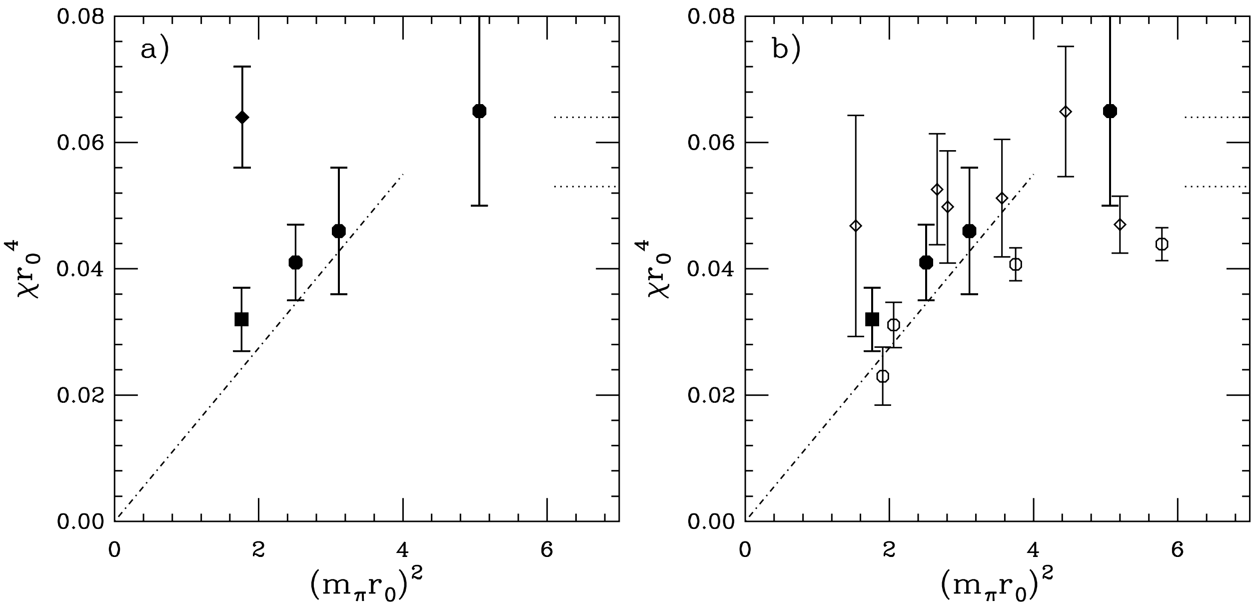
Weight $\approx \det(M)^{n_f/4}$

Roots of determinant?

Right in P.T. (weights loops correctly)

Topological susceptibility:

A. Hasenfratz, hep-lat/0104015



Filled Octagons: "HYP" action, $a \approx 0.08$ fm, (Columbia)

Filled Diamond: "HYP" action, $a \approx 0.17$ fm, (MILC)

Filled Square: "HYP" action, $a \approx 0.10$ fm, (MILC)

Open Octagons: UKQCD Clover

Open Diamonds: SESAM/TχL Wilson

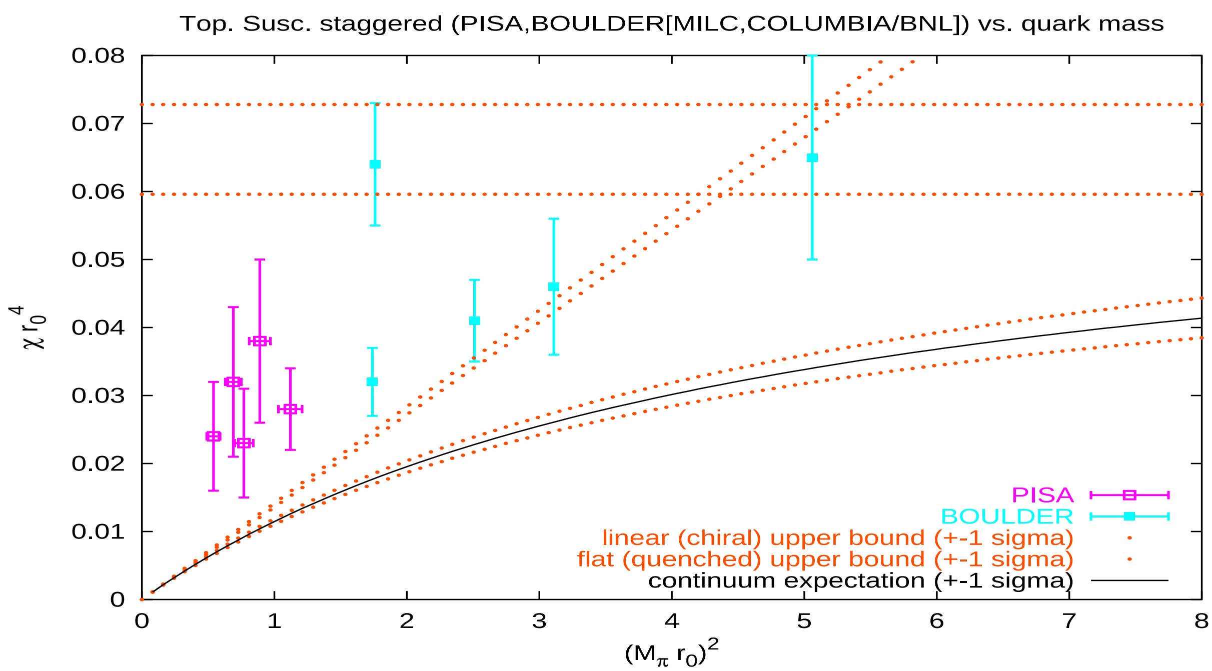
Topological susceptibility:

S. Dürr. hep-lat/0108015

Add Pisa group's data: (Conv. KS action)

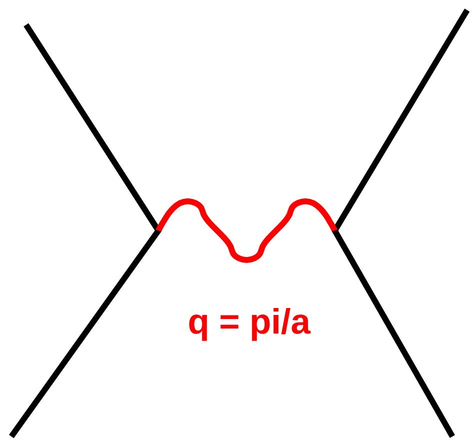
Alles *et al.*, hep-lat/0010068, Nucl. Phys. (Proc.Suppl.) **94** (2001) 441.

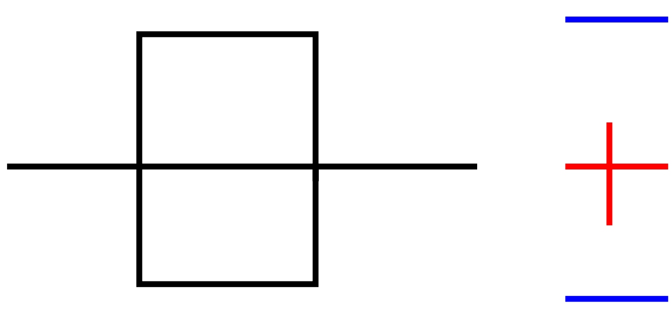
Interpolation between chiral limit and quenched limit well below chiral form for $(m_\pi r_0)^2 \geq 2$



Improved Kogut−Susskind Actions

Fix Lorentz symmetry and flavor symmetry





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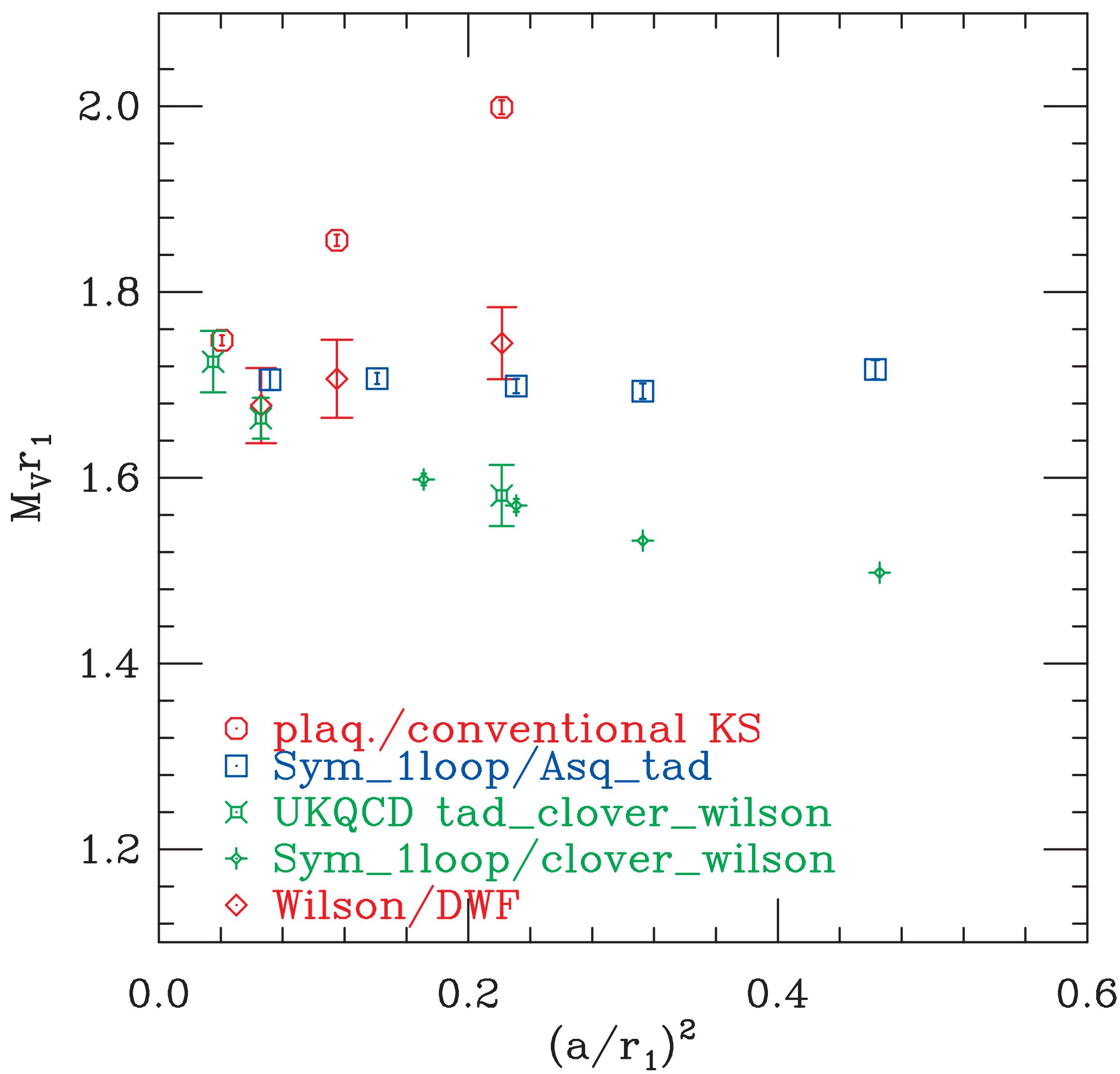
U.M. Heller, F. Karsch and B. Sturm, hep-lat/9901010, Phys. Rev. D 60, (1999) 114502

P4 action: F. Karsch, hep-lat/9706006, NPB Proc. Suppl. 60A, 169 (1998), B. Beinlich, A. Bicker, F. Karsch, E. Laermann, A. Peikert, hep-lat/9709157, Nucl. Phys. (Proc.Suppl.) **63** (1998) 895

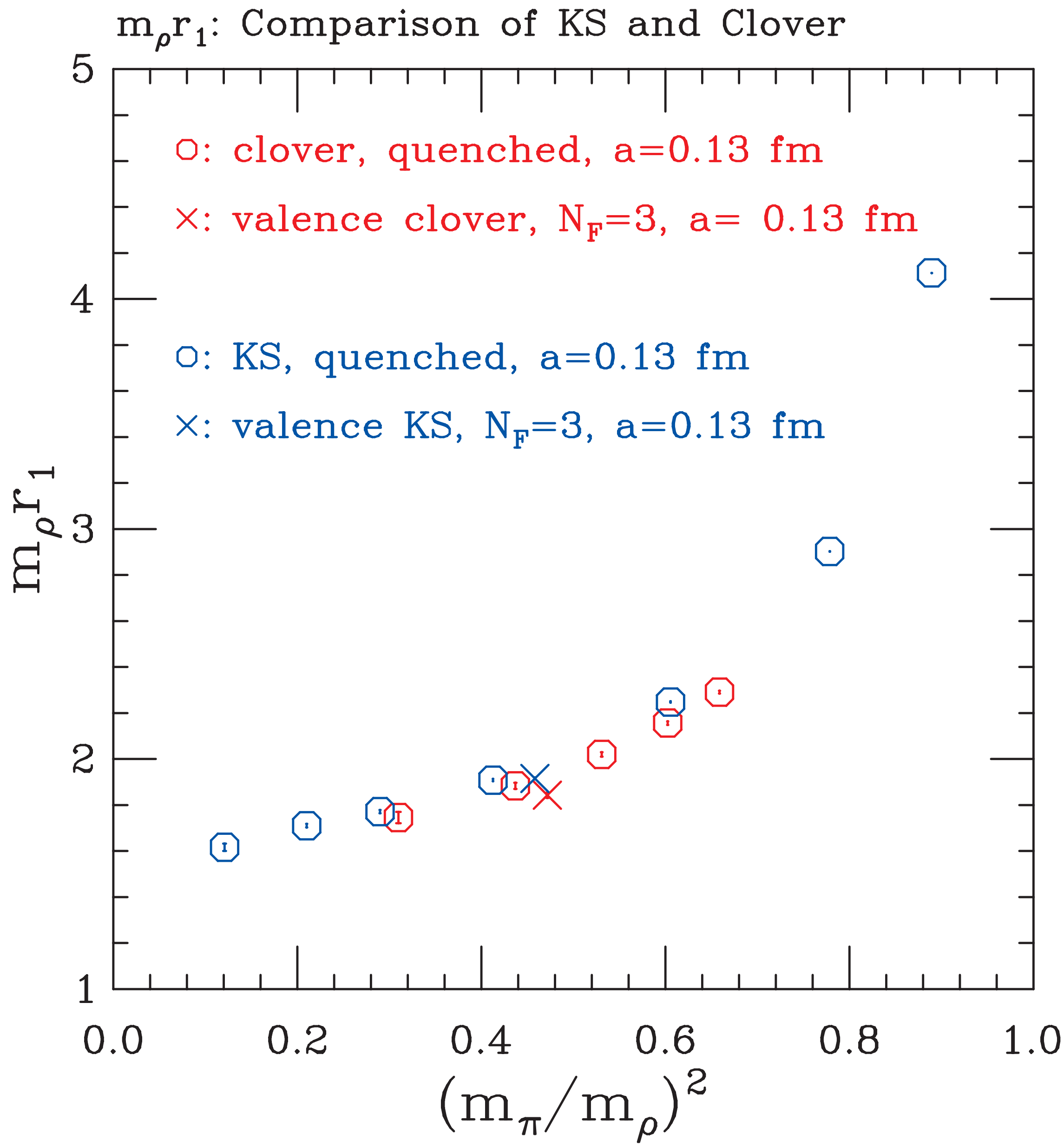
Naik action for 4 flavor thermo: O. Kaczmarek, F. Karsch, E. Laermann,hep-lat/9809059, Nucl. Phys. (Proc. Suppl.) **73** (1999) 441-443.
P4/fat action for 2 and three flavor thermo: F. Karsch, E. Laermann, A. Peikert, Ch. Schmidt, S. Stickan, hep-lat/0010040, Nucl. Phys. (Proc. Suppl.) **94** (2001) 411.

Rho mass in units from static potential



Wilson and KS rho mass on same lattices

Note this is for heavier quarks than last plot

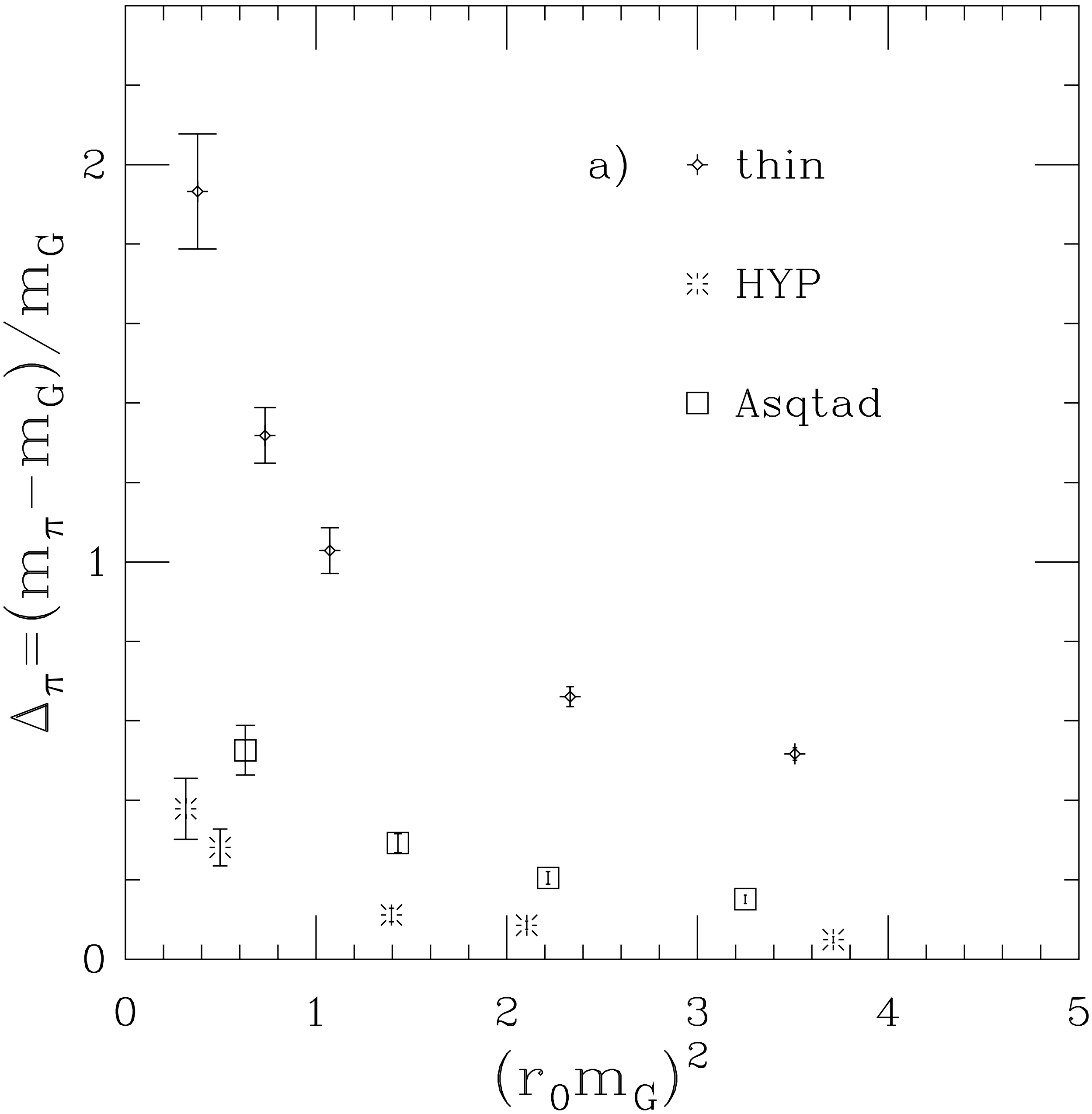


A fatlink action with unitary links

fatten, the "APE project"

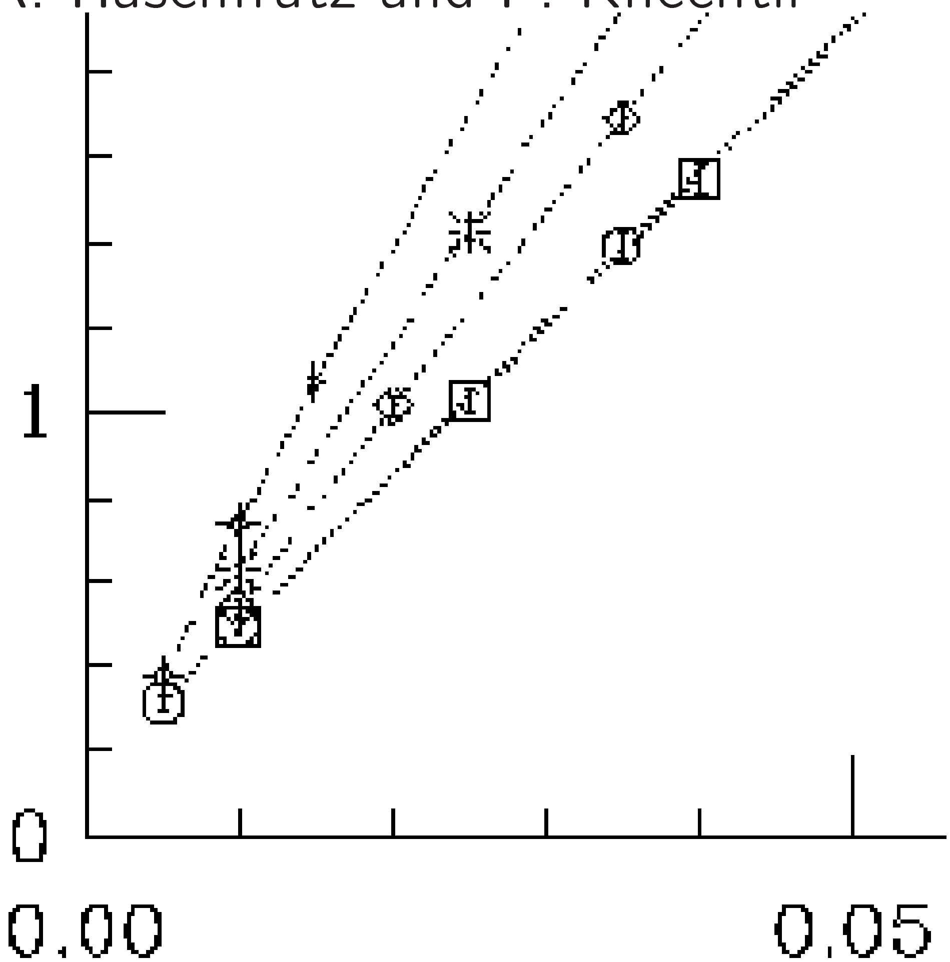
A. Hasenfratz and F. Knechtli

hep-lat/0105022, hep-lat/0106014



But the pion mass does something interesting

A. Hasenfratz and F. Knechtli



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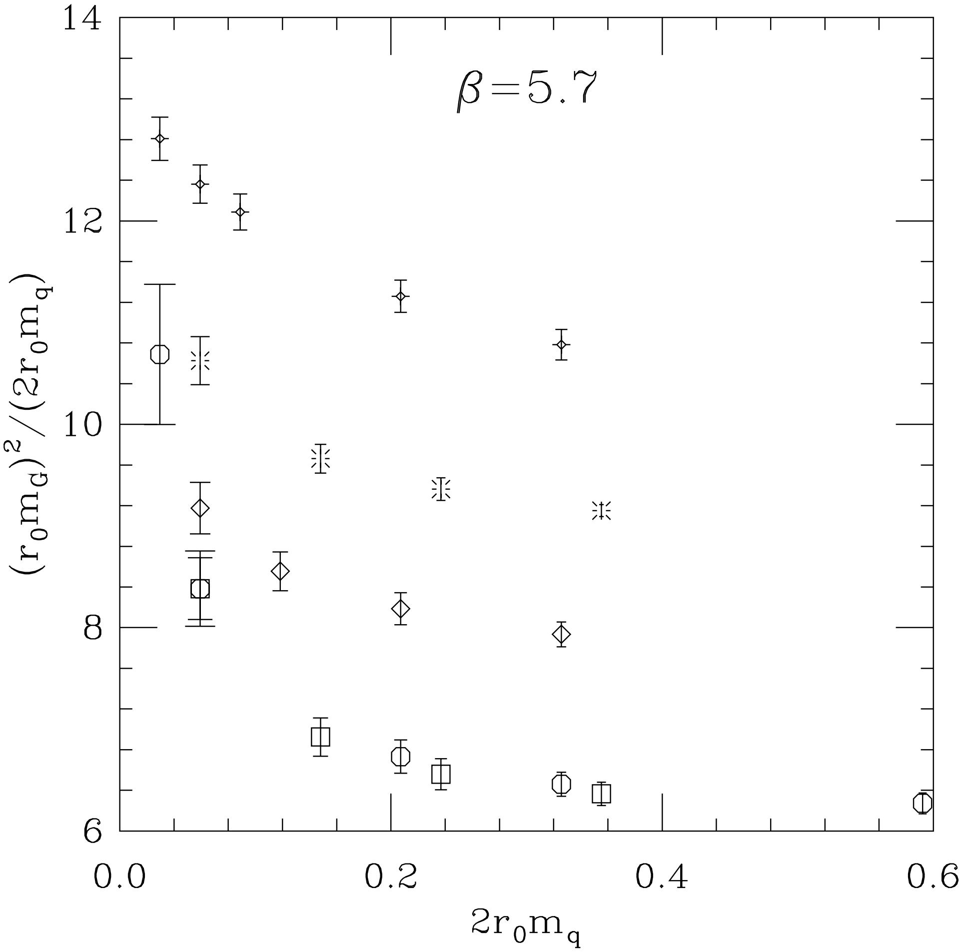
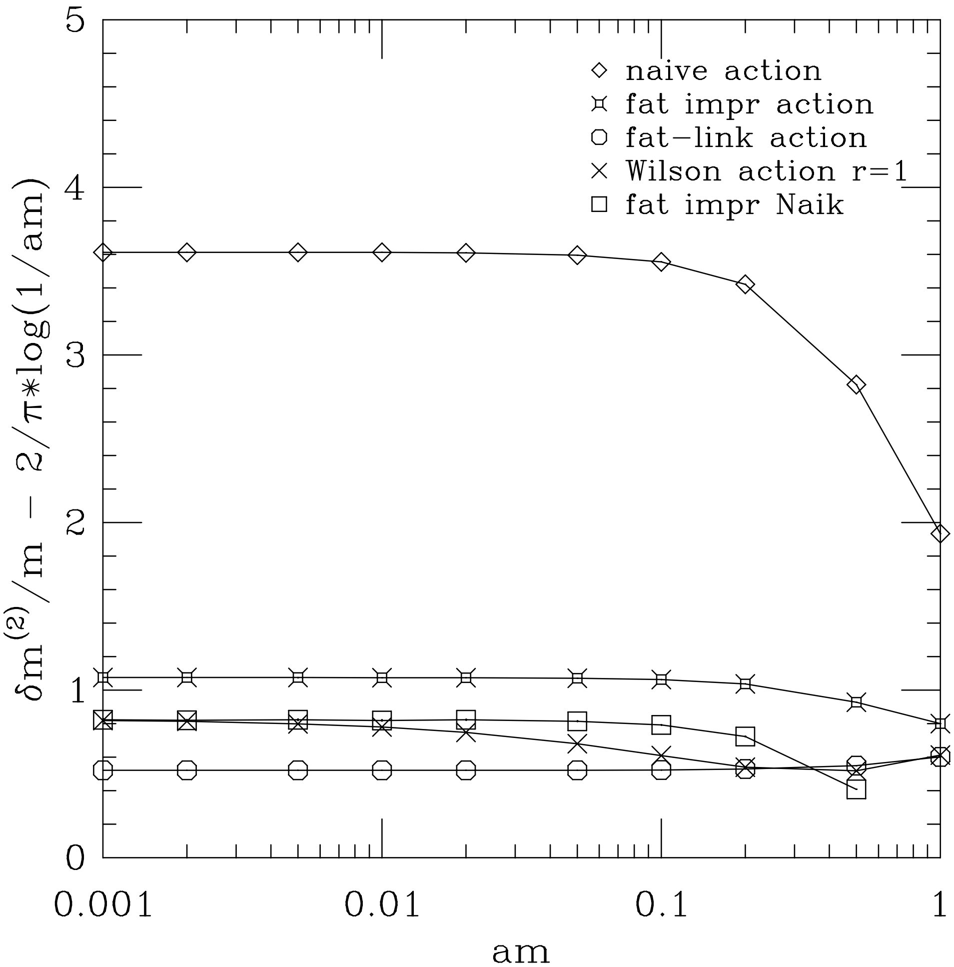


P.B. Mackenzie and M. DiPierro (this conference)
Nonperturbative tuning of "Asqtad" type action
Limited gains

Anisotropic lattices
L. Levkova and T. Manke (this conference)
Motivated by thermodynamics, but could also be used for spectrum
Esp. glueballs, hybrids, other difficult particles

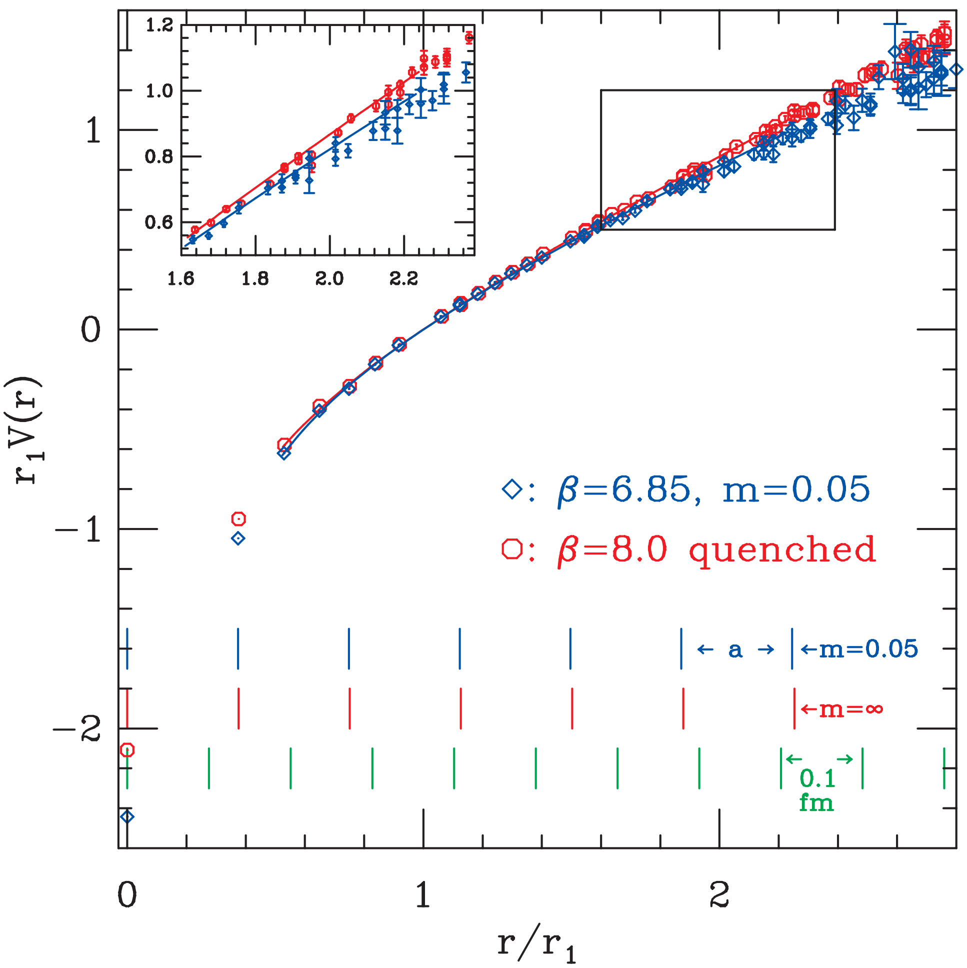
one loop quark mass renormalization

J. Hein, G.P. Lepage, Q. Mason, J. Trottier



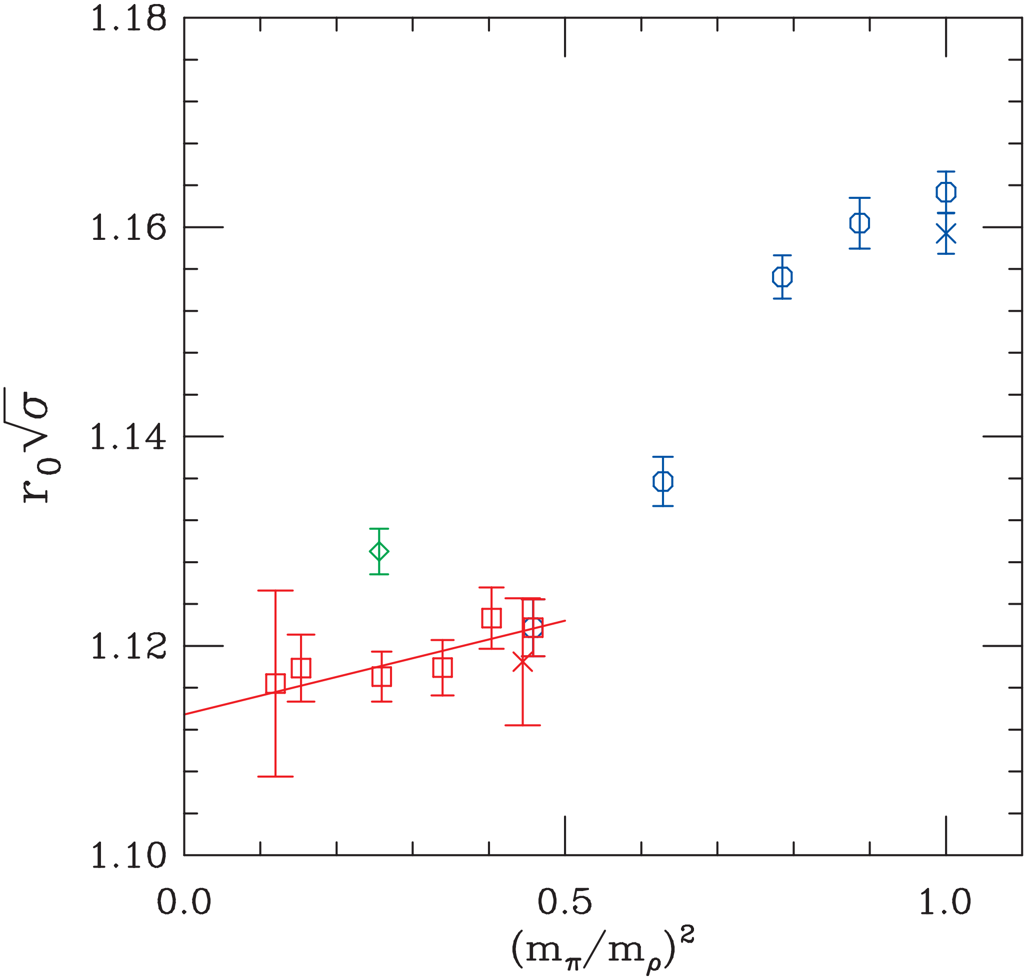
Also order $a^2\alpha_s$ flavor changing, bilinear and 4-quark operators are being done

Static potential
Effects of sea quarks



Shape of potential

$r_0\sqrt{\sigma}$



□: two light and one strange quarks

◯: three degenerate quarks

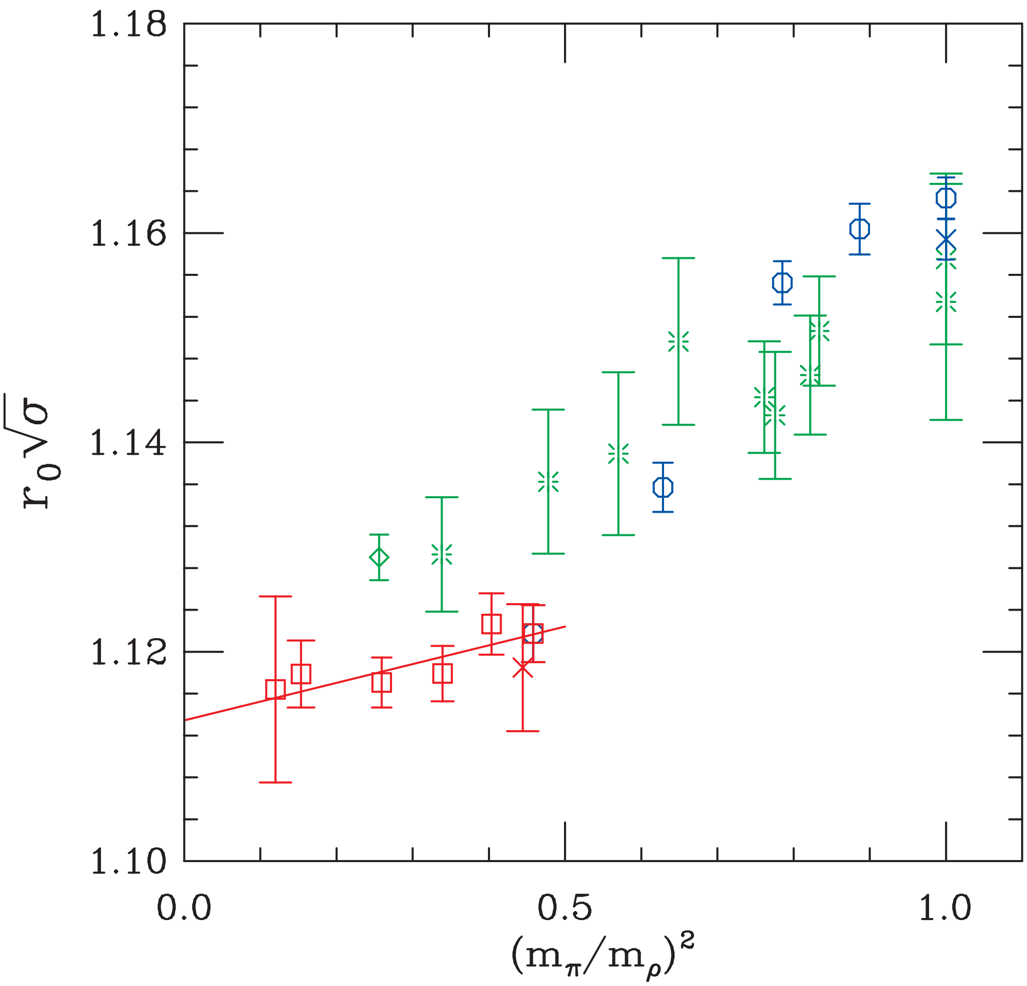
⋄: two degenerate quarks

Matched lattices, $a \approx 0.13$ fm, improved actions

Add some CPPACS two flavor (Wilson) points

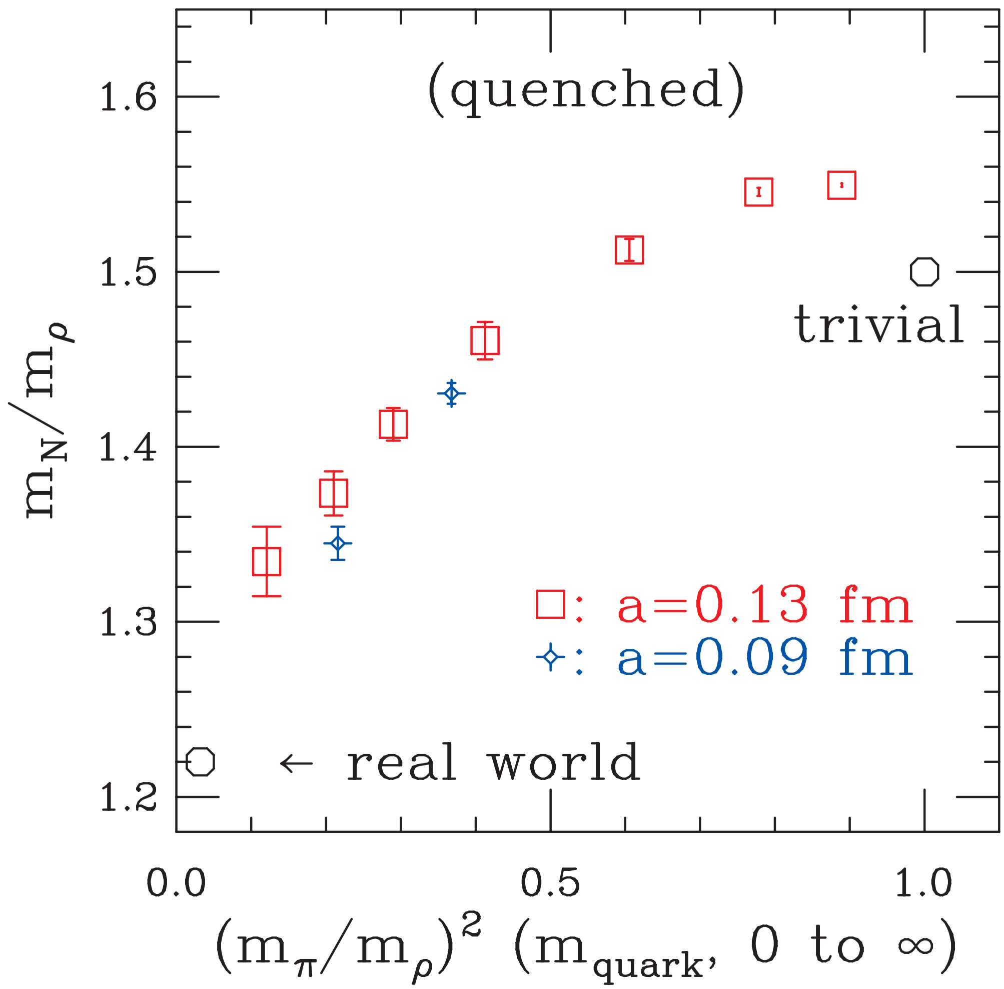
CPPACS: hep-lat/0105015

Naive error computations (mine)

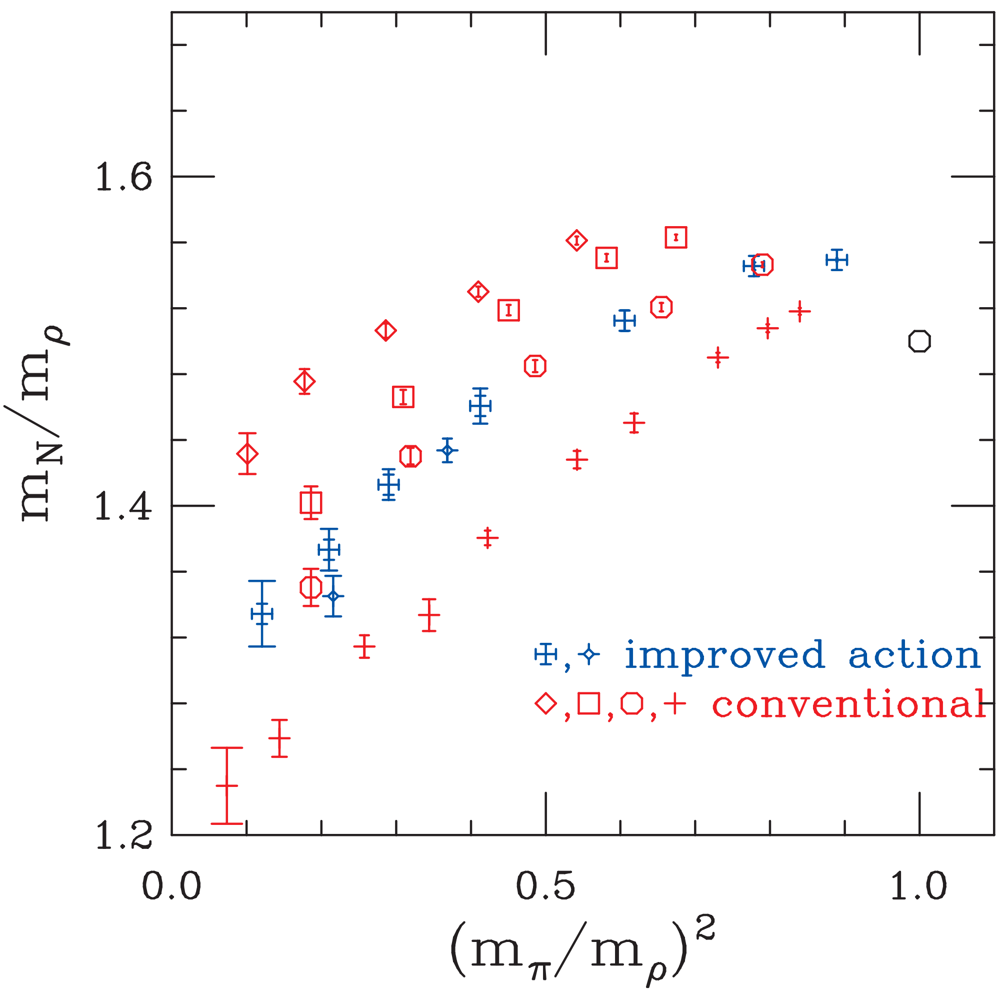


ALso UKQCD: hep-lat/0107021, doesn't seem to show as large an effect.

Edinburgh (APE) plots
Lattice spacing dependence with improved action, quenched



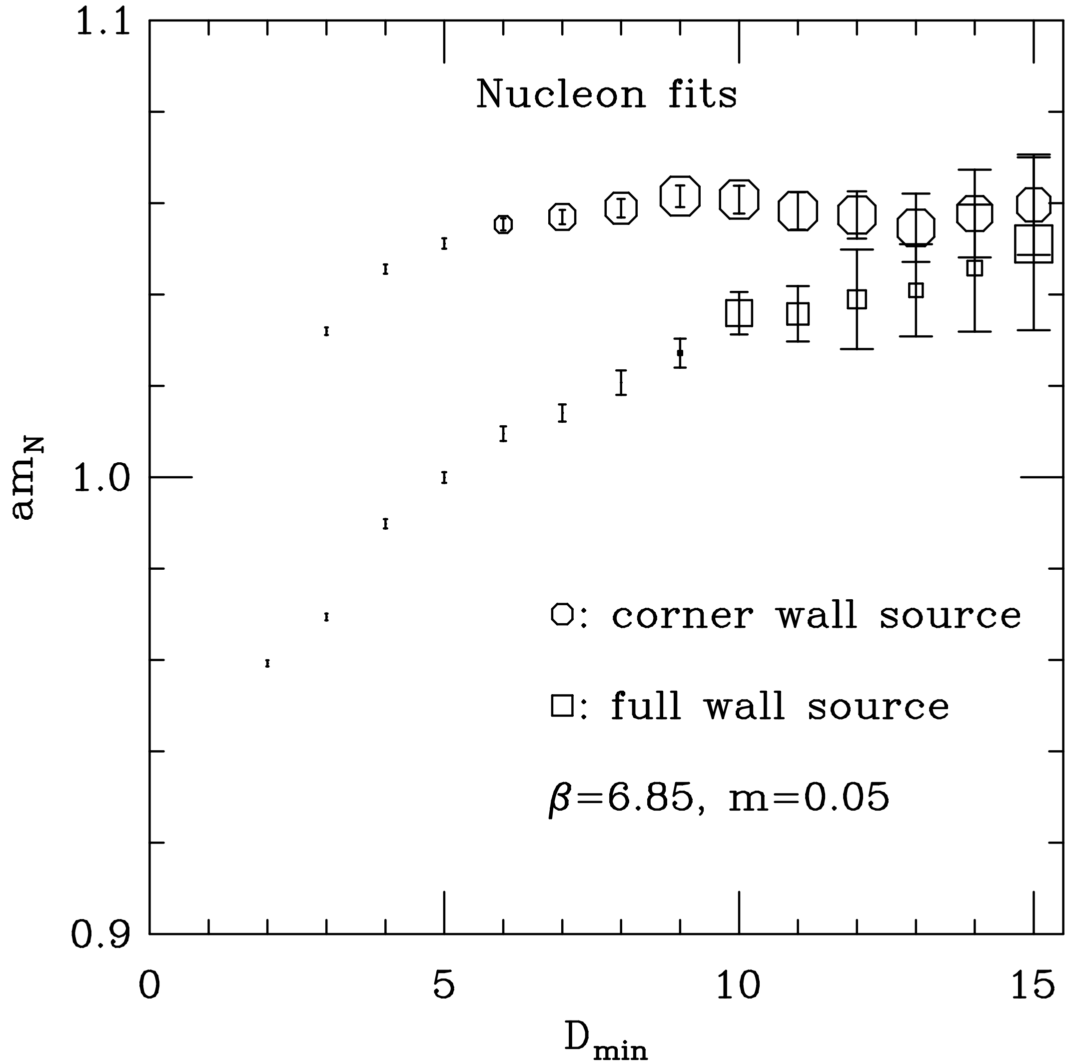
Add conventional action, with lots of lattice spacings



Improved action lattice spacings:
0.13 and 0.09 fm.
Conventional action lattice spacings:
0.16, 0.12, 0.07 and 0.043 fm
(MILC, Kim and Ohta)

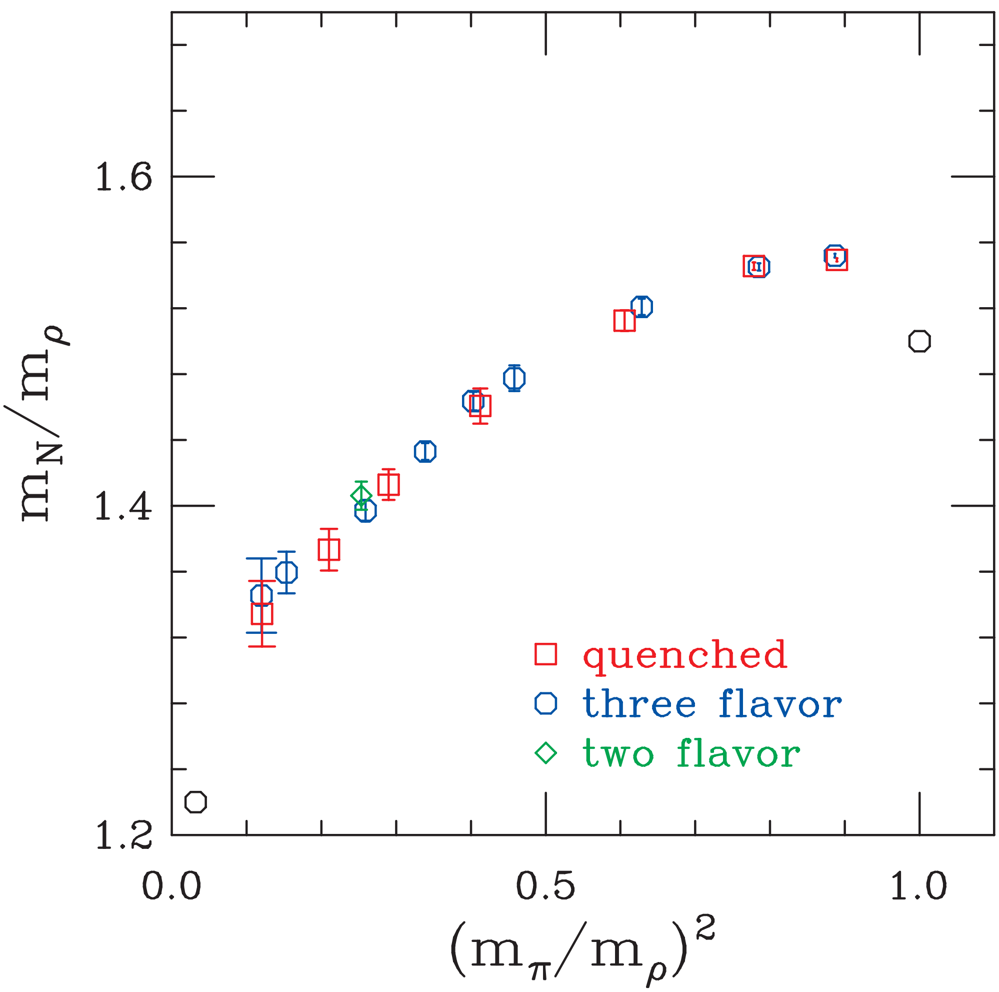
Difficulties with nucleon choices

Nucleon mass estimates versus minimum distance



Symbol size is confidence limit, symbols in legend are 50%.

Compare quenched and three flavor on matched lattices

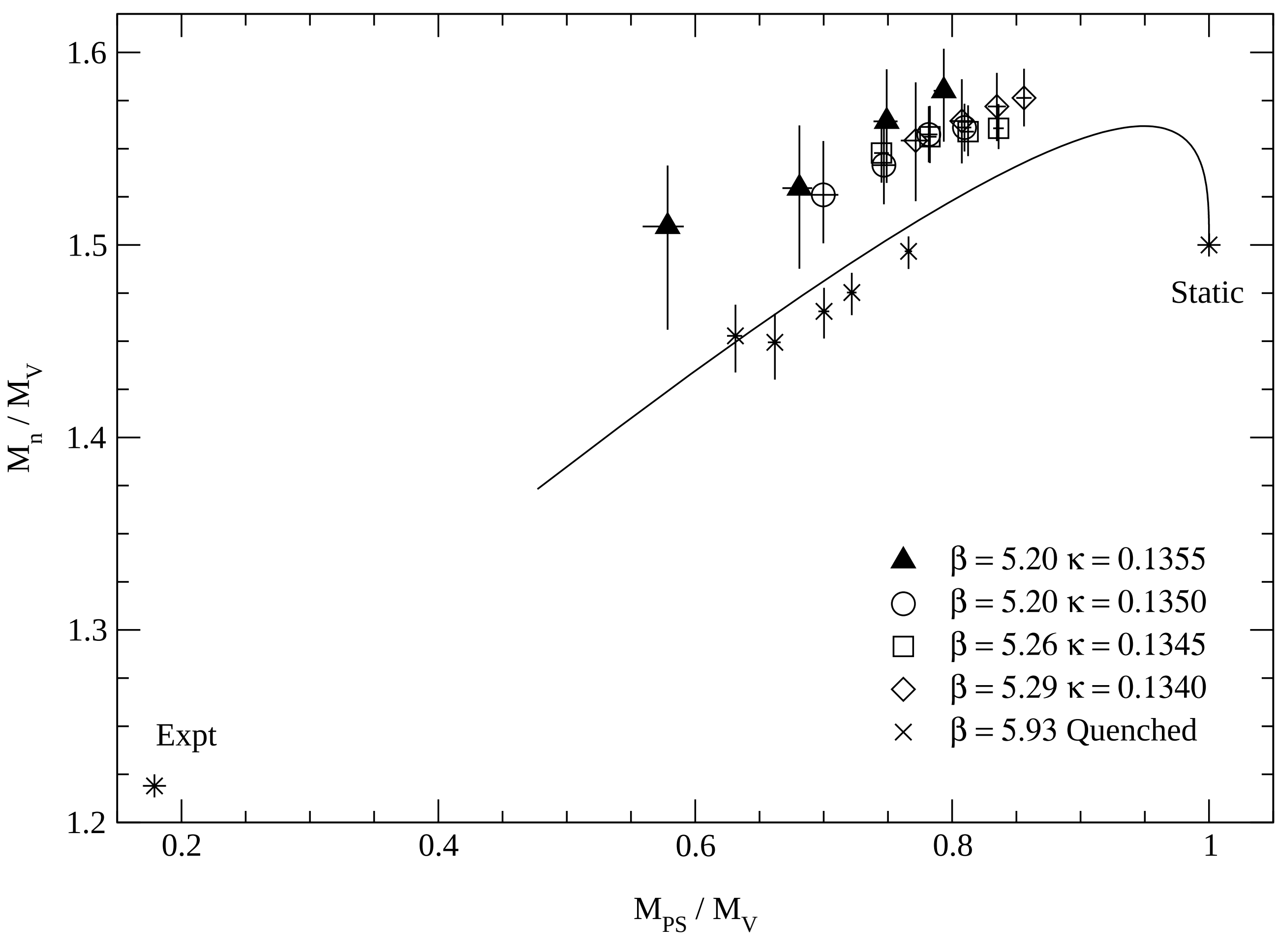


Compare to UKQCD

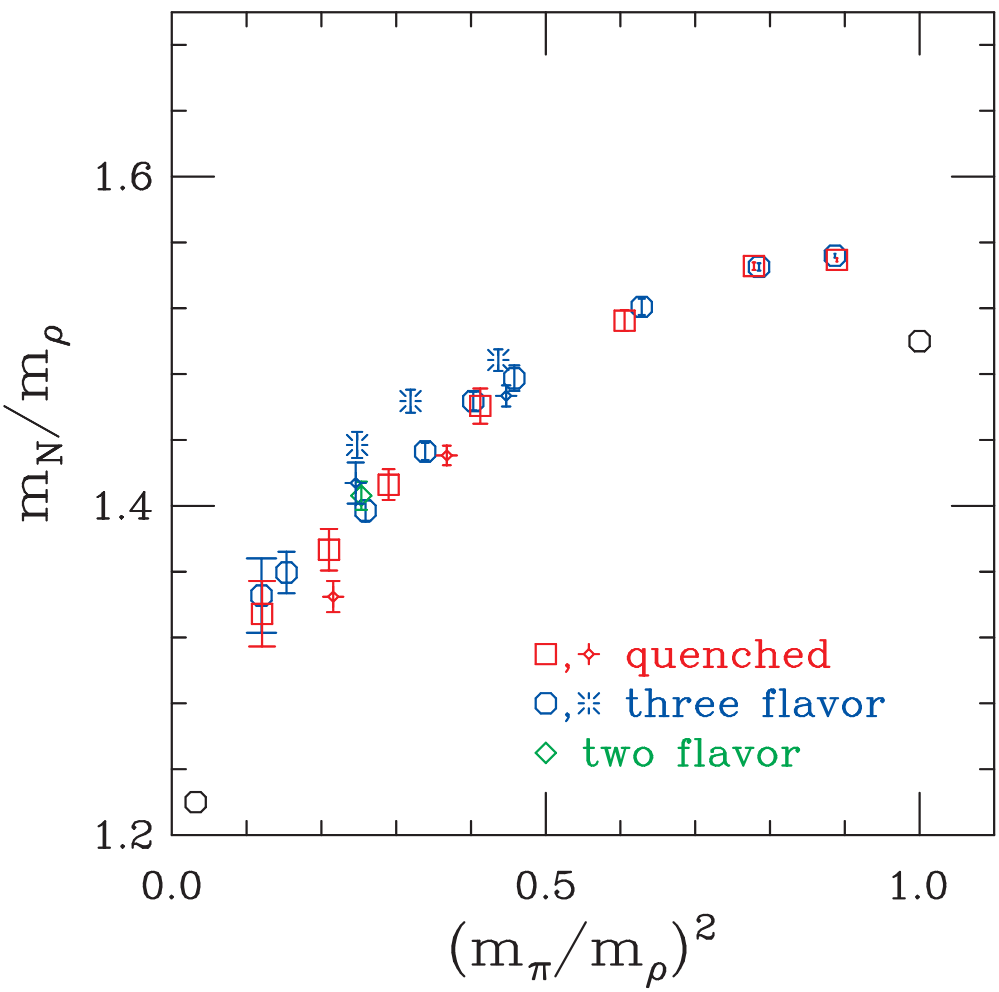
Wilson, 2-flavor and quenched on matched lattices

hep-lat/0107021

????

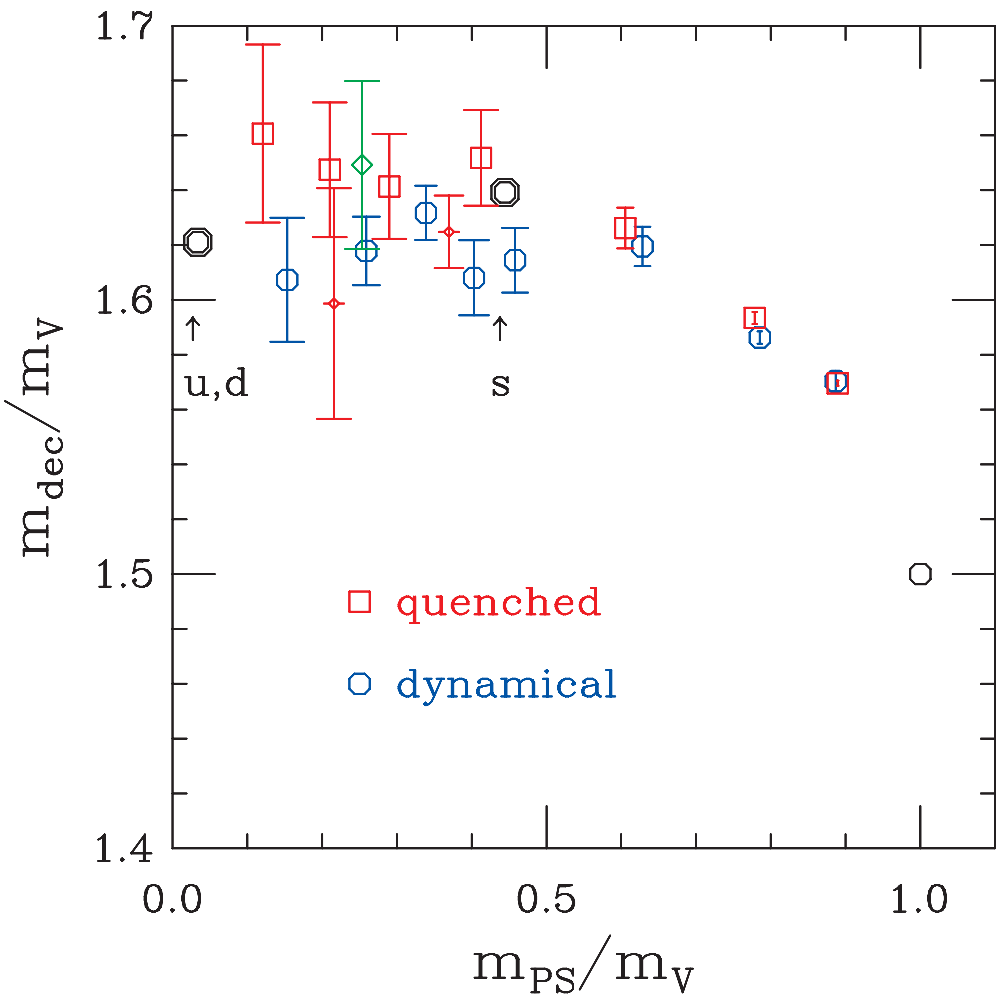


Add a few points at different lattice spacings



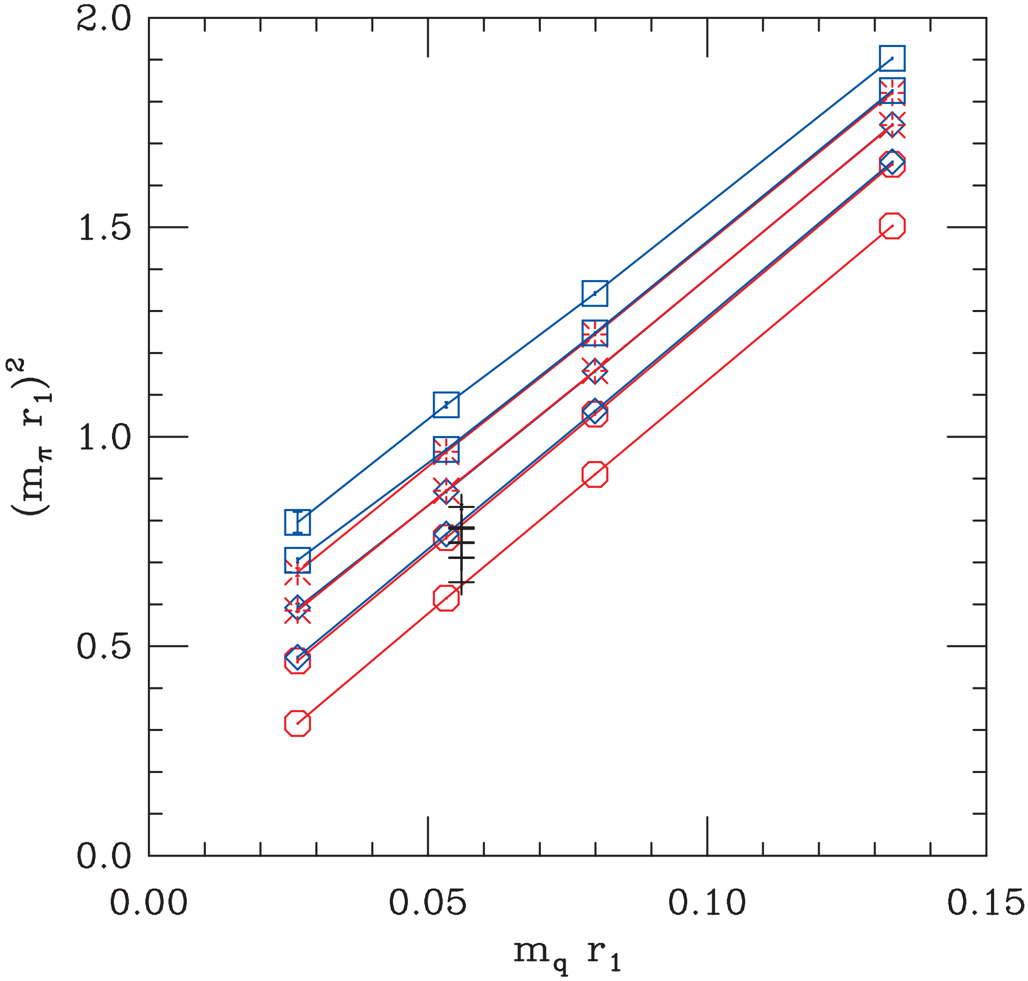
Another mass ratio, with lots of strange quarks

decuplet baryon mass / vector mass



Pion masses versus quark mass

Partial flavor symmetry restoration (Lee and Sharpe)



Highest: $\gamma_0\gamma_5 \otimes \mathbf{1}$

Then: $\gamma_0\gamma_5 \otimes \gamma_i$ and $\gamma_5 \otimes \gamma_0$

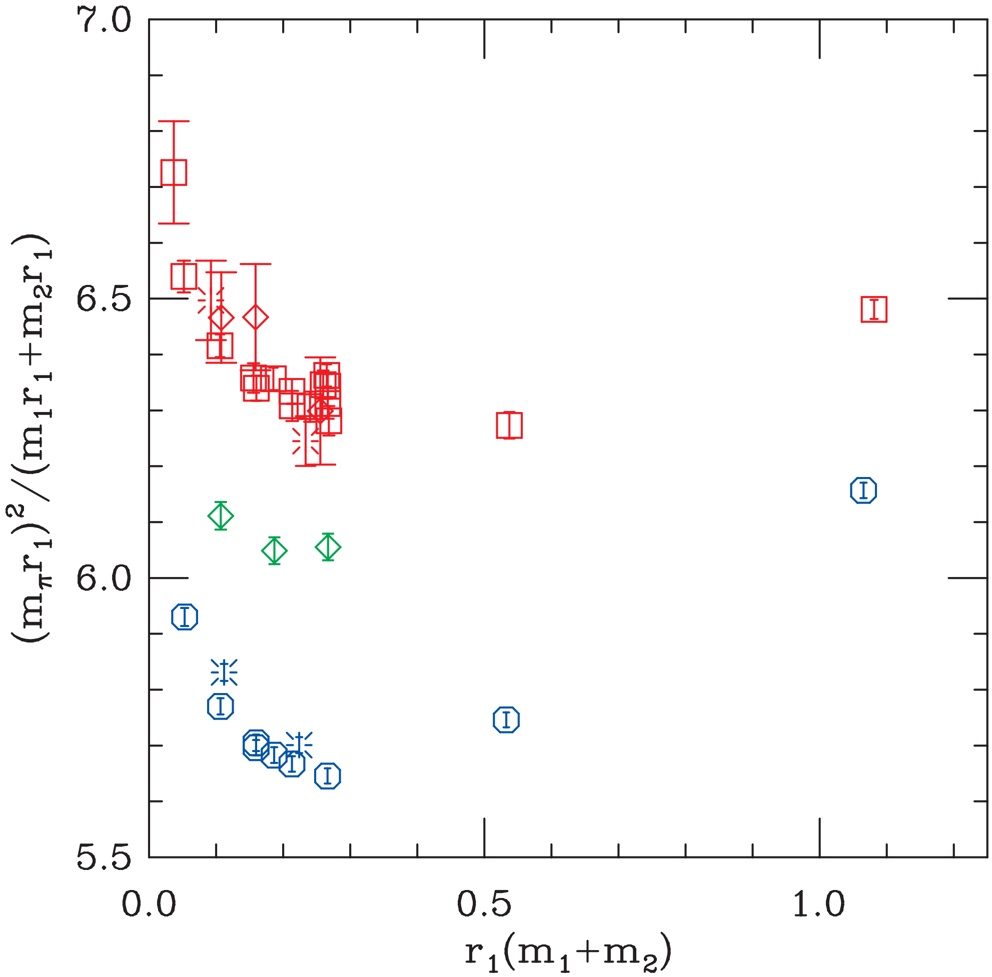
Then: $\gamma_0\gamma_5 \otimes \gamma_0\gamma_i$ and $\gamma_0\gamma_5 \otimes \gamma_j\gamma_i$

Next lowest two: $\gamma_0\gamma_5 \otimes \gamma_0\gamma_5$ and $\gamma_5 \otimes \gamma_i\gamma_5$

Goldstone pion: $\gamma_5 \otimes \gamma_5$

$+$: Finer lattice ($a \approx 0.09$ fm)

Pion chiral limit



Quenched

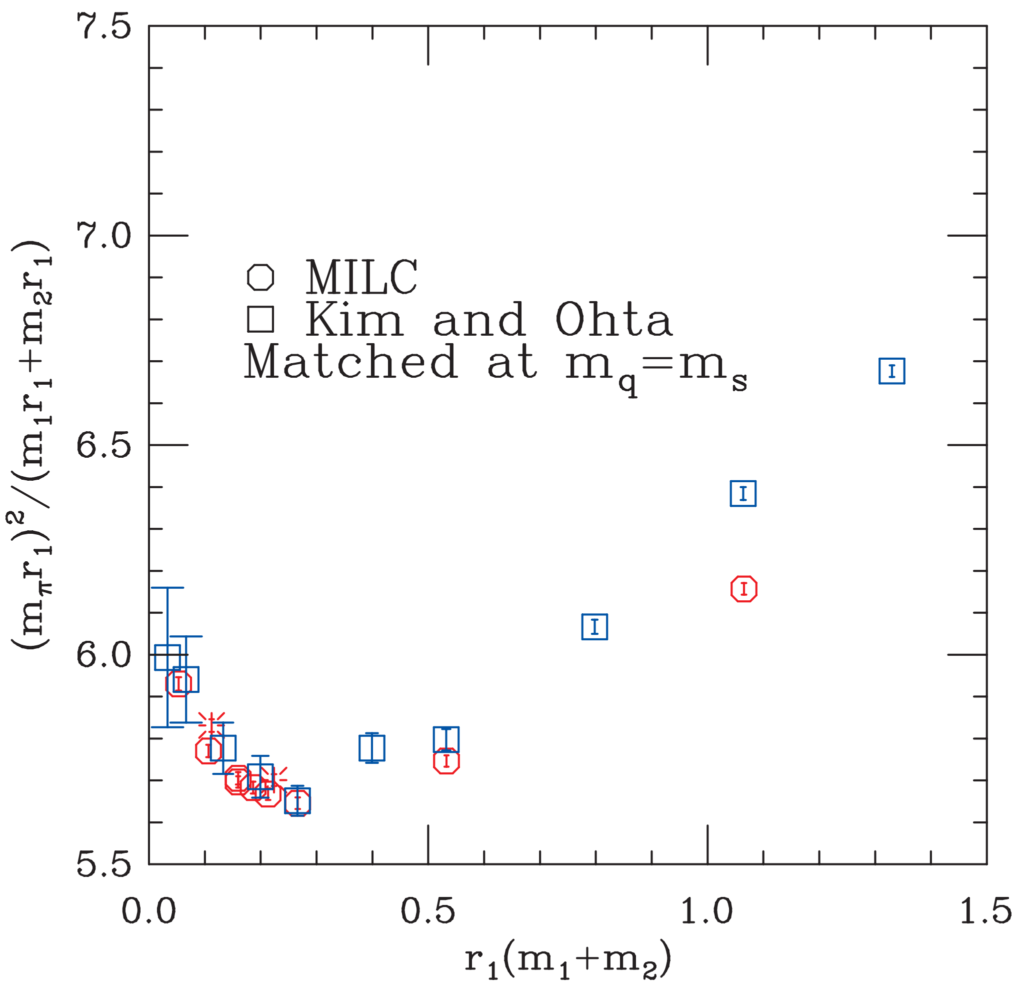
$\bigcirc$: $a = 0.13$ fm, $*$: $a = 0.09$ fm

Two flavor

Three flavor

Compare to Kim and Ohta

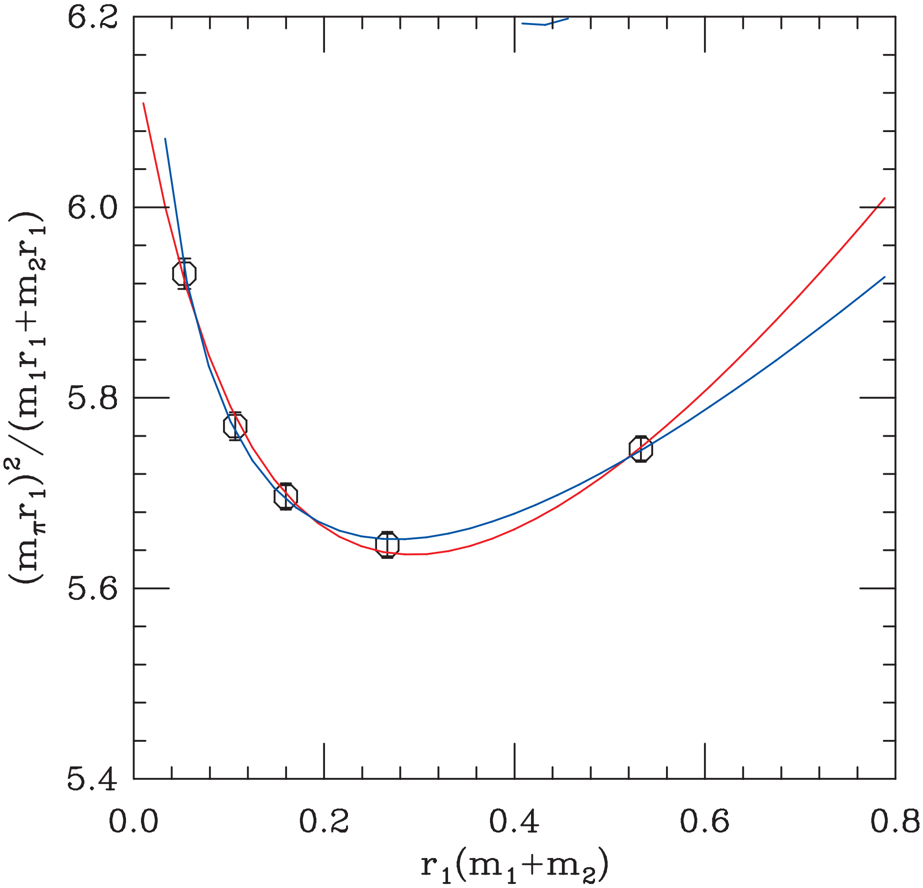
Kim and Ohta: quenched conv. action, $6/g^2 =$ 6.5) ($a \approx 0.046$ fm)



Horizontal and vertical axes arbitrarily rescaled to match at strange quark.

Chiral fits to quenched data

Claude Bernard



Red is with flavor breaking, gives $\delta = 0.14$

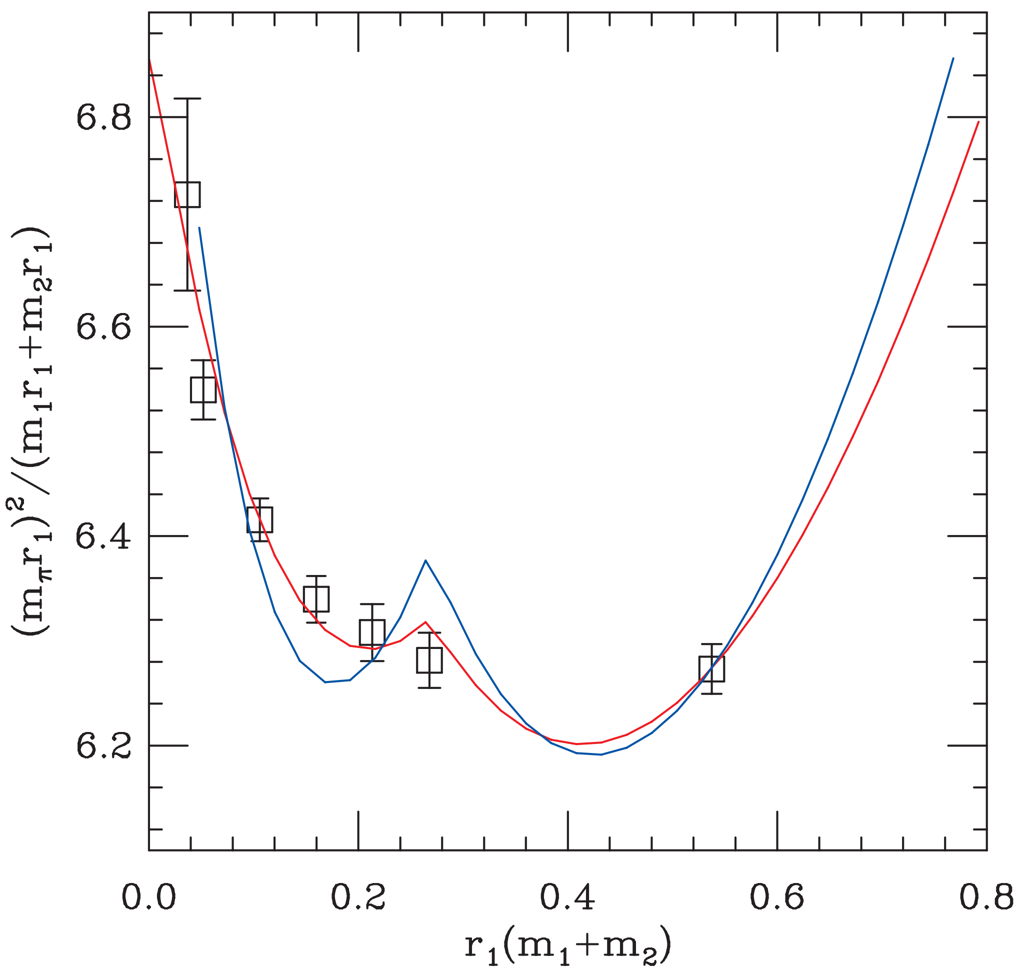
Blue is without flavor breaking, gives $\delta = 0.06$

(real world $\delta \approx 0.18$)

cf Fermilab $\delta = 0.06$ (Wilson)

Chiral fits to full data

Claude Bernard



Red is with flavor breaking

Blue is without flavor breaking

δ is fixed to real world value

Cusp is 2-flav — 3-flav switchover.

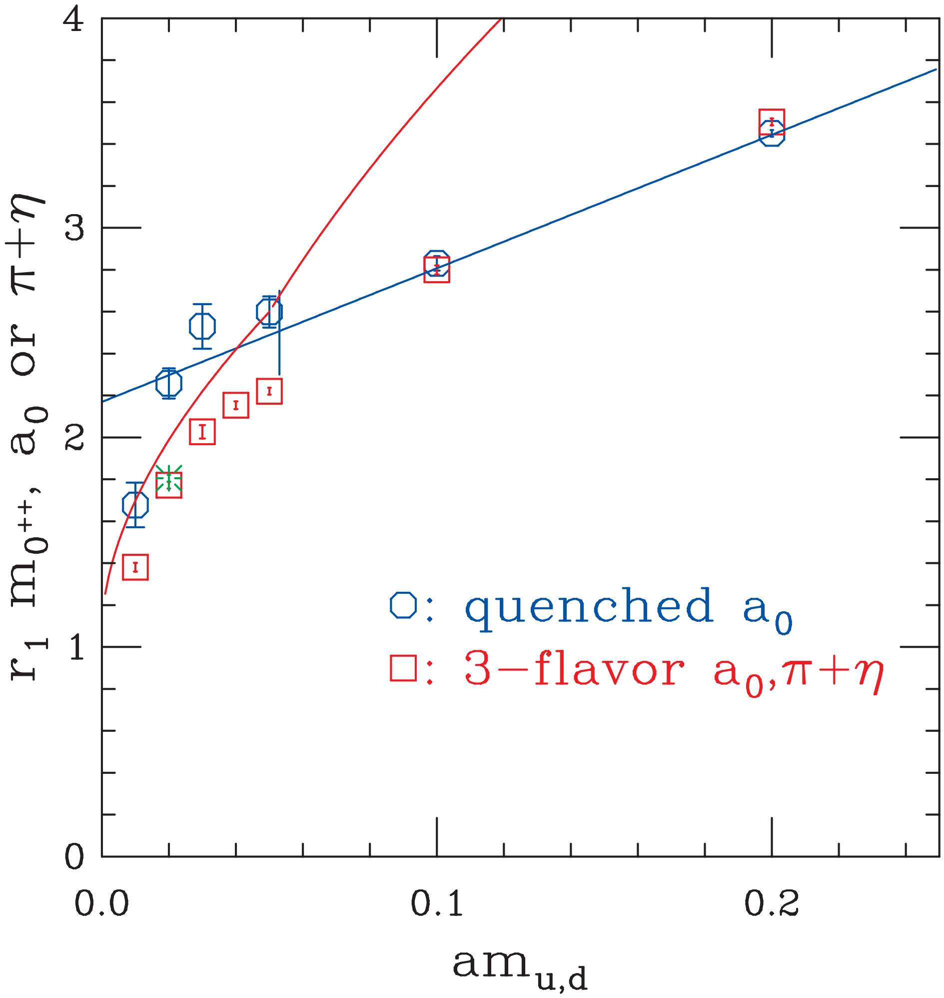
rho decay - needs nonzero momentum

won't ever happen on 2.6 fm lattice

$2 \times \frac{2\pi}{2.6\ \mathrm{fm}} \approx 960\ \mathrm{MeV}$

Meson decay

Try the a_0 (0^{++})

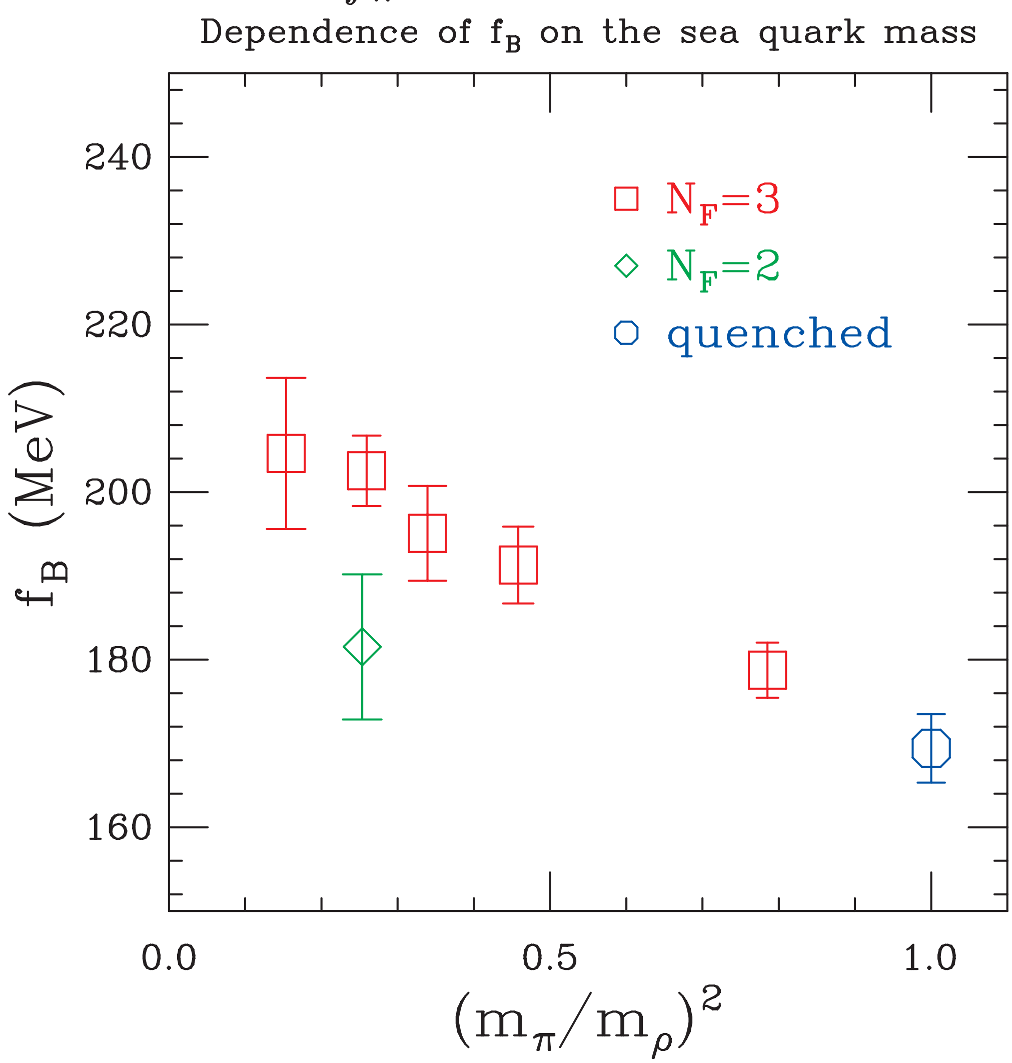


Sea quark effects?

f_B

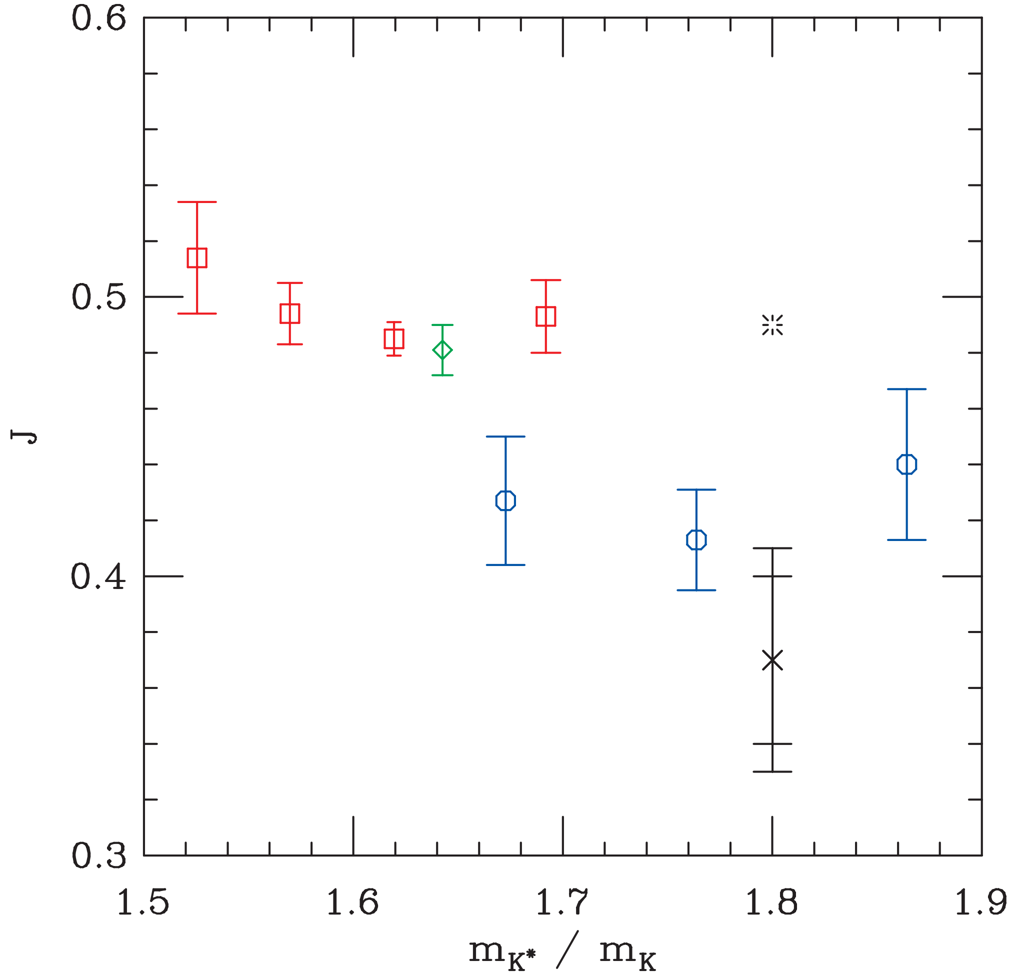
Claude Bernard

In units of f_π



Sea quark effects?

"J" with and without quark dynamics



$$J = m_{K^*} \frac{\partial m_V}{\partial m_{PS}^2} \approx \frac{m_{K^*}\left(m_\phi - m_\rho\right)}{2\left(m_K^2 - m_\pi^2\right)}$$

○ — 0 flavors

◇ — 2 flavors

□ — 3 flavors

× — UKQCD quenched

∗ — real world

CPPACS and UKQCD computations of J with Wilson quarks

Two dynamical flavors

CPPACS: hep-lat/0105015, UKQCD: hep-lat/0107021